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The effect of leaf trichome density on stem mechanical strength in *Salvia leucophylla*, *S. mellifera*, and *S. apiana*.

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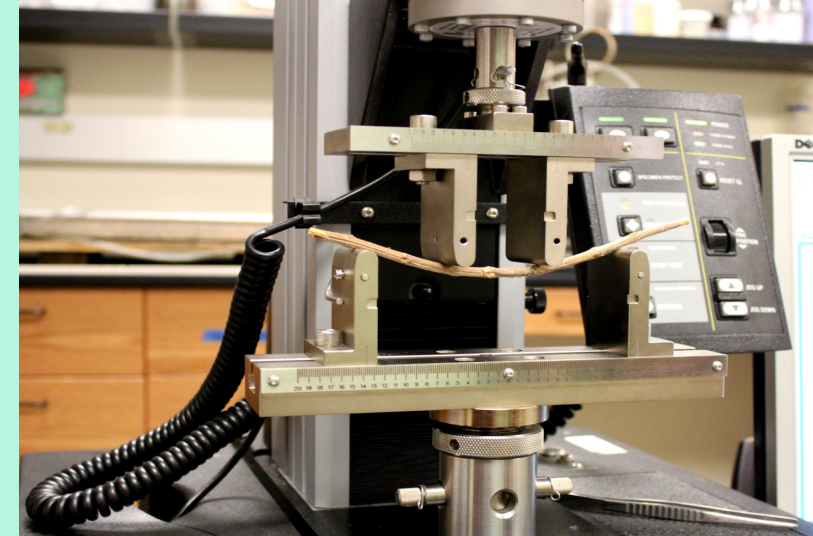
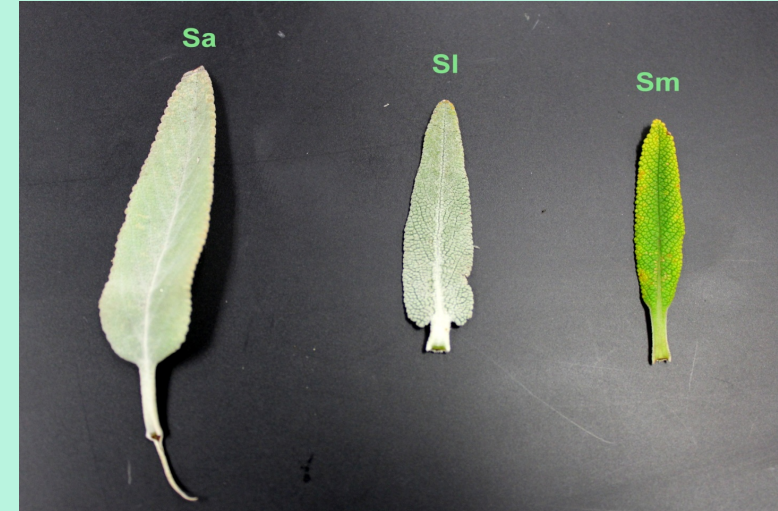
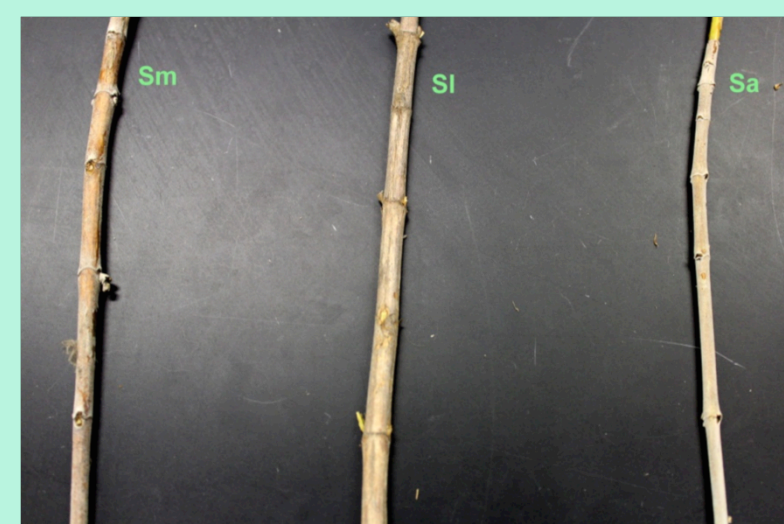
Abstract

Salvia species in southern California exhibit a variety of leaf trichome densities. *S. mellifera*, *S. leucophylla*, and *S. apiana* were chosen as study organisms because they exhibit varying trichome densities. A UniSpec was used to measure NDVI in leaves and an Instron was used to measure stem mechanical strength. This study provides preliminary evidence that suggests plants with high leaf trichome density have less stem mechanical strength, and those with low leaf trichome density have greater mechanical strength. Data generated from this study supports the idea that this may be a general and loose trend amongst plant families similar to Lamiaceae.

Introduction

In the natural world, resources are always limited. Resource allocation, therefore, is important for all living organisms to deal with one way or another—it is a game of economics. In the Mediterranean-type climate, little rainfall creates high water stress for vegetation. Interestingly, many studies have shown that Mediterranean-type vegetation is well adapted to tolerate water stress. Amongst *Salvia* species in southern California, *Salvia mellifera*, *Salvia leucophylla*, and *Salvia apiana* are very common. The three different species are aptly called black, purple, and white sage respectively. Their unique colors are partially influenced by leaf trichome density. Plant trichomes are anatomical adaptations that may benefit the plant in many ways. It is suggested that just one of these benefits is that leaf trichomes increase the water stress tolerance of a plant. The trichomes likely create several insulating layers above the stomata. When water transpires from the stoma, the water vapor normally escapes into the atmosphere. When trichomes are present, the water vapor doesn't escape into the atmosphere as freely, but rather remains in a small pocket of air between the leaf surface and the trichome layers. These layers may have a much higher relative humidity than the surrounding atmosphere in result. If these layers surround the stomata, the higher relative humidity decreases water stress by allowing water vapor to transpire from the leaf at a slower rate. Other studies have shown plant mechanical strength to increase resistance to cavitation caused by water stress. Within the *Salvia* family, we predict that *S. mellifera* has allocated more resources to building xylem fibers (and thus has higher mechanical strength) than *S. apiana* and *S. leucophylla*, which have instead invested their resources in leaf trichomes.

Sm (*Salvia Mellifera*), SI (*Slavia Leucophylla*), Sa (*Salvai Apiana*)



Jeff Scanlon Preparing stems for the Instron.

Instron measuring mechanical strength of a stem.

Works Cited

1. Pérez-Estrada, L. B., Cano-Santana, Z. & Oyama, K. Variation in leaf trichomes of *Wigandia* urens: environmental factors and physiological consequences. *Tree Physiol* **20**, 629–632 (2000).
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3. Grammatikopoulos, G. & Manetas, Y. Direct absorption of water by hairy leaves of *Phlomis fruticosa* and its contribution to drought avoidance. *Canadian Journal of Botany* **72**, 1805–1811 (1994).
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Results

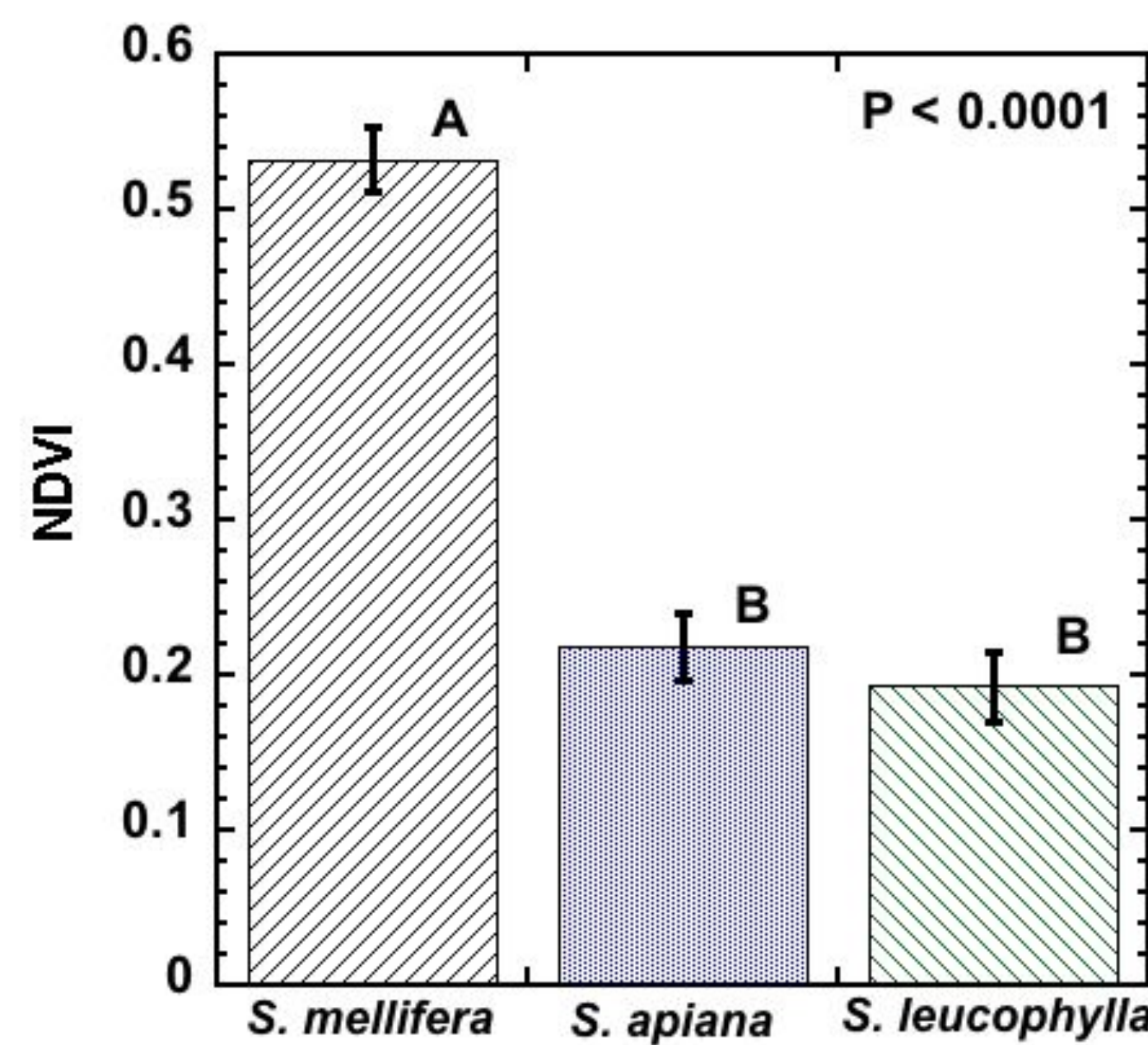


Figure 1: The average Normalized Difference Vegetation Index (NDVI) of Sm, Sa, and SI – which assesses whether the sample being observed contains live green vegetation or not.

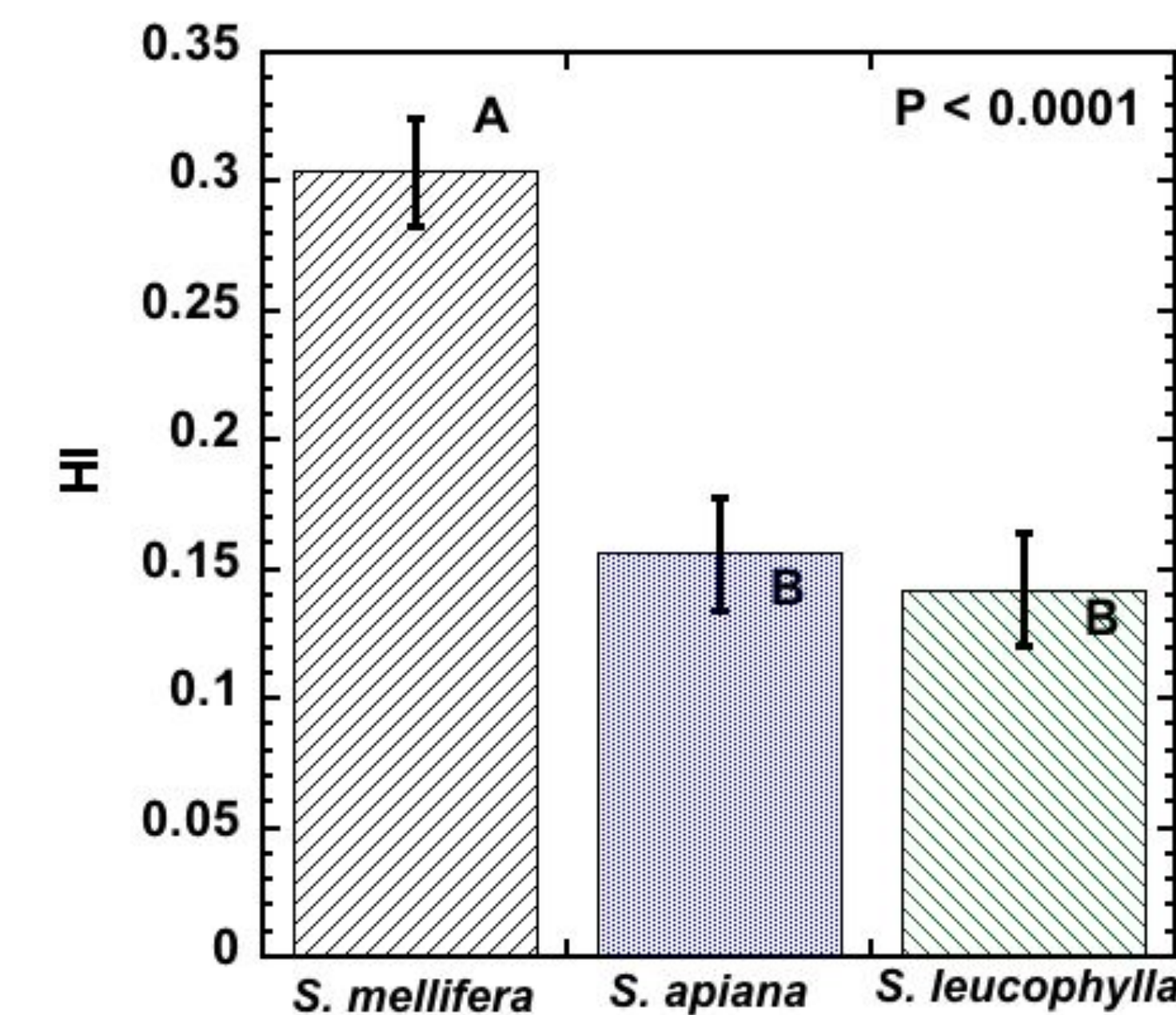


Figure 2: A generated Hair Index (HI) from the collected NDVI data. This data reflects the area of the graph (550-630nm) that demonstrated significant difference (Figure 6) between Sm, Sa and SI.

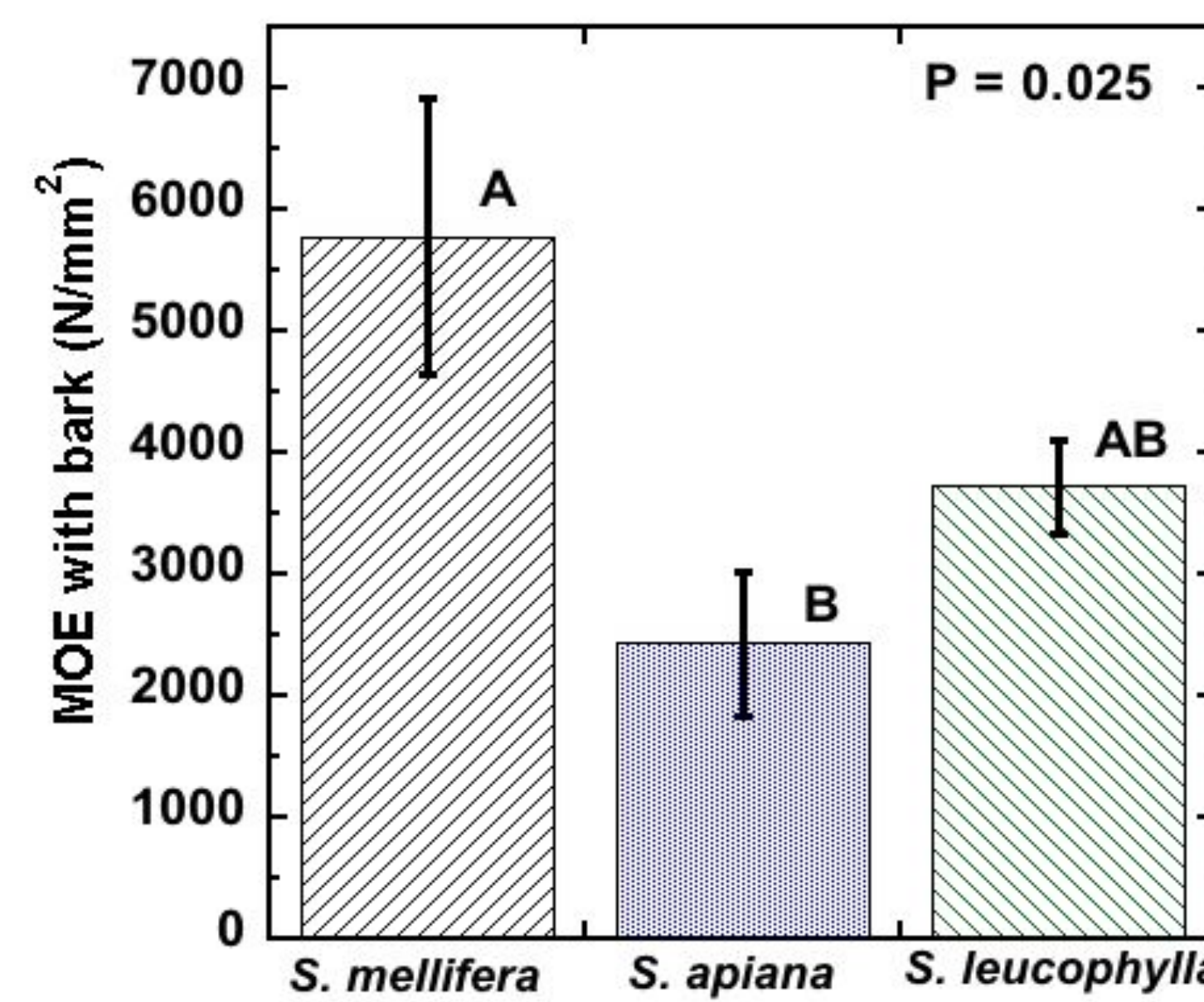


Figure 3: Comparison of stem MOE among Sm, Sa and SI by one way ANOVA followed by a Fisher's Least Significant Difference Test. The letters indicate significant difference at $p < 0.05$.

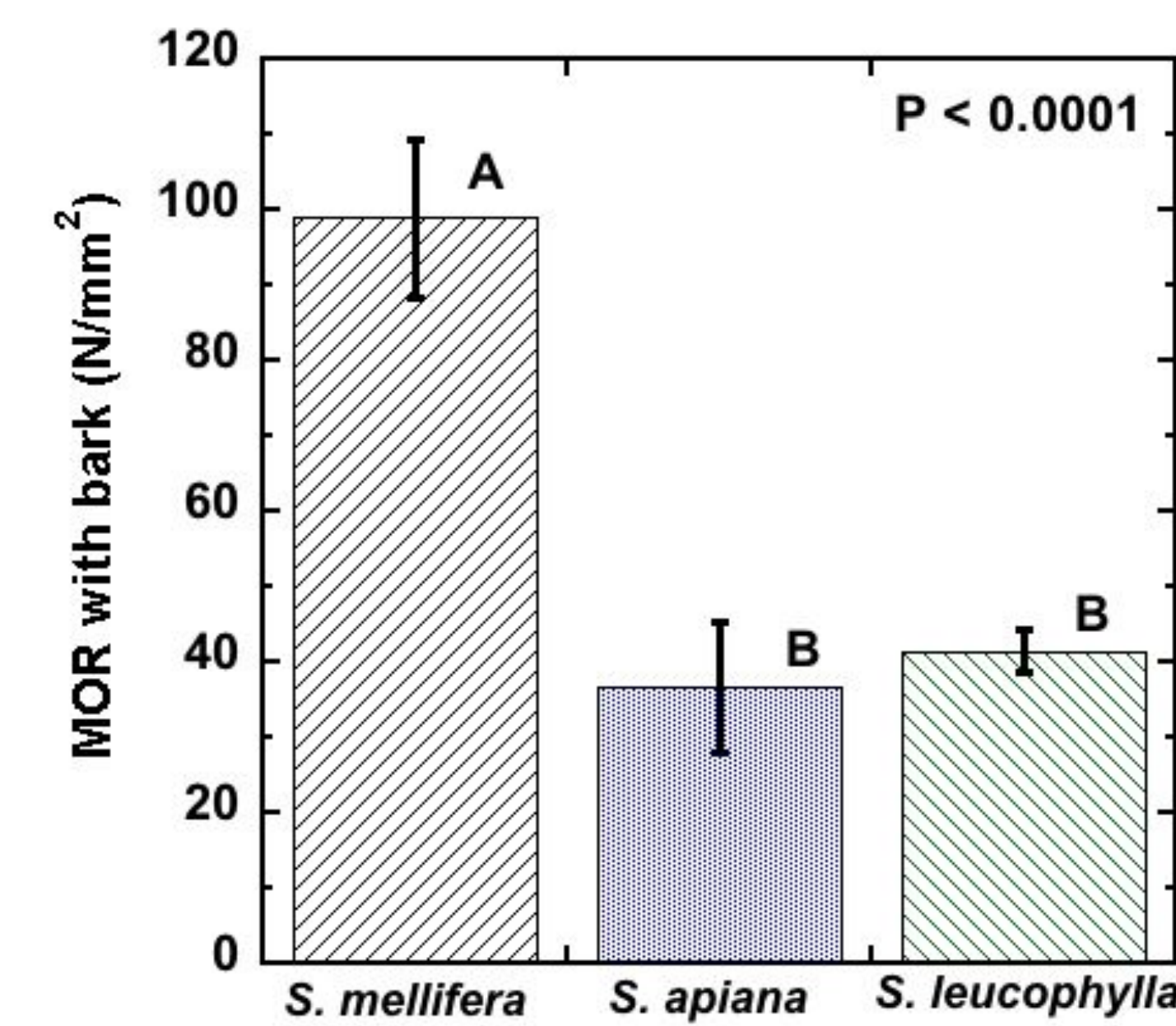


Figure 4: Comparison of mean Modulus of Rupture with bark (MORb) between Sm, Sa and SI.

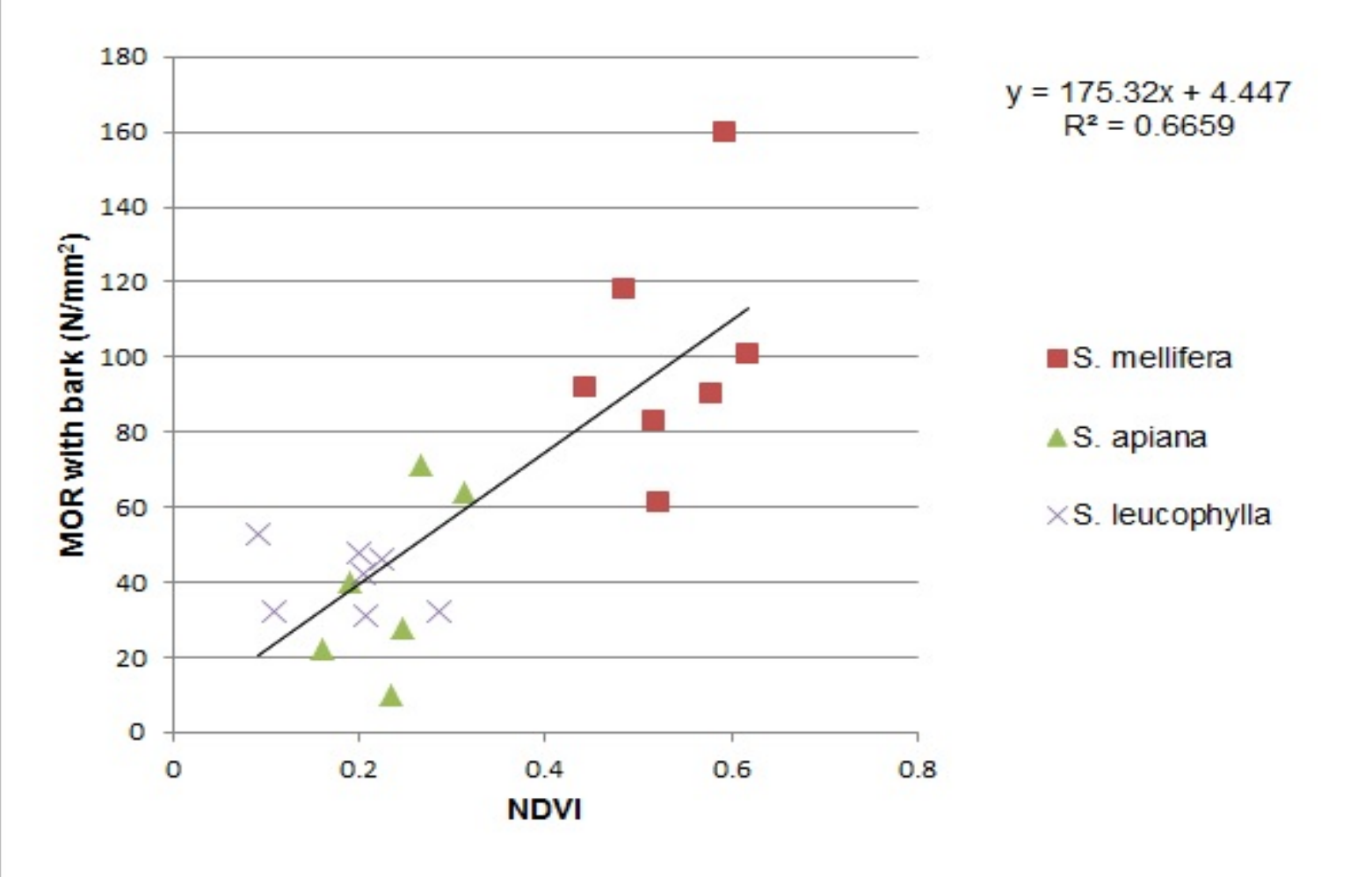


Figure 5: Illustrates the leaf trichome density and mechanical strength.

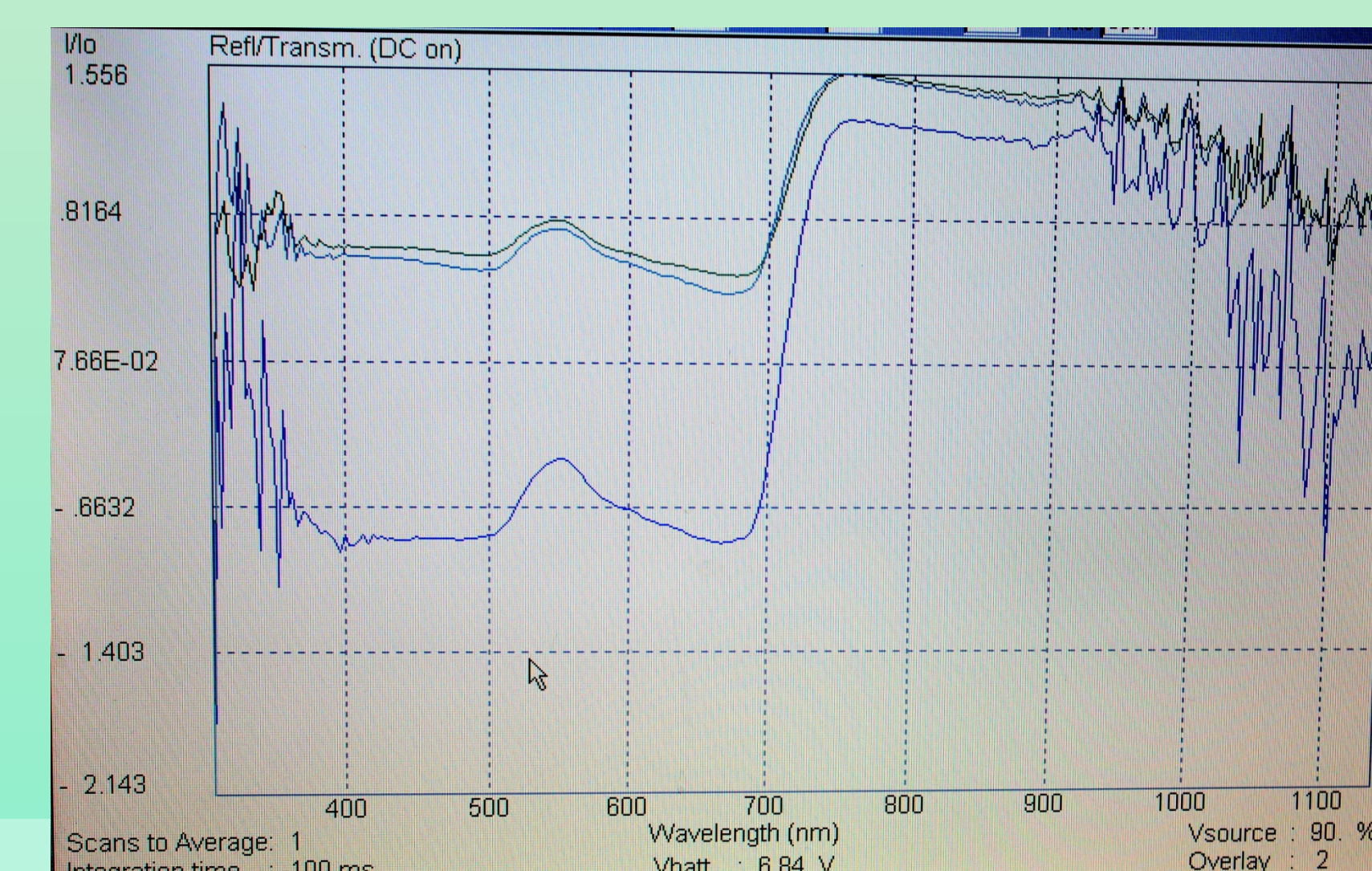


Figure 6: Measure of light reflectance b versus wavelength the UniSpec in leaves of Sm (dark blue), Sa (light blue) and SI (green)

Discussion

An ANOVA test comparing NDVI of the three *Salvia* species yielded $P < 0.0001$, which is highly significant. The ANOVA test comparing HI of the three species yielded the same results. NDVI and the Hair Index we generated targeted reflectance at wavelengths between 550 and 630 nm (green light). The statistical significance of the ANOVA tests shows that *S. mellifera* has a much “greener” leaf than both *S. leucophylla* and *S. apiana*. The comparatively lower reflectance values of *S. leucophylla* and *S. apiana* at this wavelength range indicate a higher level of leaf trichomes on these species. Thus, our ANOVA analysis may be extrapolated to suggest that there are significant differences in leaf trichome density between *S. mellifera* and the other two species. The Fisher's Least Significant Difference post-hoc test confirms that there was a significant difference between NDVI and HI of *S. mellifera* and that of *S. leucophylla* and *S. apiana*, but there was no statistically significant difference between *S. leucophylla* and *S. apiana*.

An ANOVA test for the mechanical strength data collected yielded similar results. *S. mellifera* had significantly greater MORb than both *S. leucophylla* and *S. apiana* ($P < 0.0001$). *S. mellifera* also had significantly greater MOEb than *S. apiana* ($P < 0.0079$), but did not have significantly greater MOEb than *S. leucophylla* ($P < 0.0749$).

Conclusion

S. mellifera leaves have significantly less trichome density compared to that of *S. apiana* and *S. leucophylla* leaves.

S. mellifera significantly greater stem mechanical strength than that of *S. apiana* and *S. leucophylla* stems.

Economic principals of resource allocations suggest that many plants face this type of trade off in which leaf trichome density varies inversely with stem mechanical strength. Figure 5. Supports this idea. We anticipated that *S. apiana* leaves have greater trichome density than *S. leucophylla* leaves. Our study shows they are very similar. Refined methods should be used to compare these two species in future studies.

Acknowledgements

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